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ABSTRACT

This history and state-of-the-art review of computer graphics describes computer graphics programs and proposed programs at Sheridan College (Canada), the Rhode Island School of Design, the University of Oregon, Northern Illinois University, and Ohio State University. These programs are discussed in terms of their philosophy, curriculum, student requirements, and concerns, and their relationships with one or more of the following curriculum orientations are explored: (1) behavioral, (2) subject/disciplines, (3) social, (4) developmental, (5) cognitive process, (6) humanistic, (7) transpersonal, and/or (8) technological. This analysis of existing programs is designed to serve as an aid in the development of a usable curriculum orientation for computer graphics, and design and curriculum requirements for a proposed computer graphics program for the arts are outlined. Flexibility is emphasized as a necessary ingredient for a computer graphics curriculum. (MES)

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DESIGN AND CURRICULUM CONSIDERATIONS FOR A COMPUTER GRAPHICS PROGRAM IN THE ARTS

A Thesis

Presented in Partial Fulfillment of the Requirements
for the Degree Master of Arts

by

Ruedy W. Leeman, B.S., B.F.A.

The Ohio State University
Fall, 1985

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The author would like to thank his advisor Dr. Thomas Linehan and Professor Charles A. Csuri, director of The Computer Graphics Group, for their support and encouragement. I would like to thank all the members of The Computer Graphics Group for their creative and technical support.

I would like to thank my wife, Barbara, and children, Adam and Hilary, for their patience. Also, thanks go to my parents, Hans and Martha Leeman, for giving me the drive to achieve in my endeavors and a love of life.

THESIS ABSTRACT

THE OHIO STATE UNIVERSITY

GRADUATE SCHOOL

NAME: Ruedy W. Leeman QUARTER/YEAR: Fall 1985

DEPARTMENT: Art Education DEGREE: Masters of Arts

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TITLE OF THESIS:
Design and Curriculum Considerations
for a Computer Graphics Program in the Arts

Interest in computer graphics and the creative potential computer graphics offers designers and artists, has grown rapidly in the last few years. Many universities are interested in developing computer graphics programs or assimilating computer graphics capabilities into their arts curricula. This thesis looks at computer graphics programs and proposed programs at the following schools: Sheridan College in Canada, The Rhode Island School of Design, The University of Oregon, Nothern Illinois University, and The Ohio State University. General observations are made, resulting in descriptions of necessary design and curriculum ingredients for a Computer Graphics Program in the Arts.

Thomas E. Linehan

Advisor's Signature

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ACKNOWLEDGEMENTS

The author would like to thank his advisor Dr. Thomas Linehan and Professor Charles A. Csuri, director of The Computer Graphics Group, for their support and encouragement. I would like to thank all the members of The Computer Graphics Group for their creative and technical support.

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CHAPTER 1

Introduction

1.1. Problems in Developing a Computer Graphics Curriculum

Designing a curriculum in computer graphics for artists and designers is a difficult task since computer graphics has applications in many areas of interest.

> ...the computer is extensively used as a visual analysis tool for clarifying medical and scientific data...for graphic layout, drafting, and all aspects of the print industry...in the film, television, video games, and other entertainment industries. Computer-aided product design and manufacturing design...in architecture, space planning, and interior design. In addition, the computer is used by a diversity of fine artists [2].

To design a curriculum in computer graphics we need to choose from among many possibilities. To begin the curriculum planning process some knowledge of the educational level of the proposed students should be determined. Students need to be chosen by their academic and professional background as well as their degree of

interest in computer graphics and their adaptability. The needs of specific disciplines must be assessed to determine the theoretical and conceptual directions to be taken for the development of computer graphics relative to these disciplines. Last, but not least, the interest of the students needs to be assessed to determine their needs and desires. All the above criteria need to be taken into account when designing a curriculum structure for implementing computer graphics for artists and designers.

> We emphasize again that educators must obtain as much pertinent data as possible about the young people to be educated. A curriculum is aways planned for students, and about the society that establishes and controls the schools [27].

The needs of society are ever changing especially relative to computer graphics. Computer graphics is used by architects, industrial designers, interior designers, product designers and commercial animators to name a few. The needs of tomorrow's society must be considered as well. Computer graphics is in it's beginnings and is developing at a very rapid rate. This implies that curriculum designers must anticipate the future needs of society.

> Curriculum planning must be an ever-continuing cycle of obtaining data, defining objectives, providing learning experiences, evaluating instructional outcomes, reexamining data, and appraising goals in light of all factors [27].

The above mentioned computer graphics users will seem small in number compared with the applications of tomorrow. All these considerations need to be taken into account when developing a curriculum in computer graphics for artists and designers.

1.2. A Brief History of Computer Graphics

To offer some insight into the complexities of designing a curriculum in computer graphics, it is helpful to look at the history as well as the projected future of computer graphics. Computer graphics had it's beginning in the 1960's.

> The single event that did more to promote interactive computer graphics as an important new field was the publication in 1962 of a brilliant thesis by Ivan E. Sutherland, who had just received his Ph.D. from MIT. This thesis, entitled Sketchpad: A Man-Machine Graphical Communication System, proved to many readers that interactive computer graphics was a viable, useful, and exciting field of research [24].

Sutherland's work was the impetus for other research projects at MIT, General Motors, Bell Telephone Laboratories, and Lockheed Aircraft. The first users of these systems were researchers and scientists.

> The first computer art exhibitions, which ran almost concurrently in 1965...were held not by artists at all, but by scientists: Bela Julesz and Michael Noll at the Howard Wise Gallery, New York; and Georg Nees and Frieder Nake at Galerie Niedlich, Stuttgart, Germany [4].

Artists were drawn toward this new medium of expression and realized that they needed to work with scientists to be able to attain access to the new technology. The results of some of the collaborations between artists and scientists were shown in:

> ...three large-scale shows: "Cybernetic Serendipity" organized in London for the Institute of Contemporary Art bu Jasia Ruchand (1968), "Some More Beginnings,"...organized by Experiments in Art and Technology at the Brooklyn Museum, New York (1968), and "Software," curated by Jack Buenham at the Jewish Museum in New York (1970) [4].

Most of the visual output was produced with pen plotters and line printers, making the results slow to attain and of course image quality. Animations were done by filming each plotted still frame in sequence, processing the film and projecting the film to determine if the motion was

what the artist desired. There were some vector displays that were capable of supporting real time animation but for the most part, artist were unable to attain access to these vector display systems. One of the first computer graphic art shows to incorporate these interactive vector displays was organized by Professor Charles Csuri through the College of Art at the Ohio State University in 1970 [4]. This was the beginning of real involvement by artists.

The seventies were the years in which the research of the sixties began to produce results. Besides the development of interactive paint systems for artists, a major effort was made to develop three dimensional systems that used raster displays capable of supporting a CAD/CAM system and animation. More and more artists began working with scientists to aid in the development of custom-designed programs capable of meeting their needs. This first generation of artists focused on mathematics and logic to manipulate their imagery. This seemed at that time to be a rather abstract method. But artists needed to be able to understand the workings of the computer to be able to communicate with the scientist and to propose changes that were possible or compatible with the

configuration of the computer.

Three events improved the possibilities for artists working with computer graphics. First, the invention of the microprocessor made the computer inexpensive enough for artists to access a system that was capable of supporting computer graphics to some degree. Second, interactive systems that simulated painting, drawing, photography and videotaping became common in the creative work space. Third, raster graphic displays allowed almost unlimited choices of color plus the capabilities of three dimensional smooth shaded images. "These three advances combined to foster the migration of computer technology into art schools and artists' studios as well as commercial production houses." [4]

1.3. The Present State-of-the-Art

Colleges have just begun to the development of computer graphic programs for artists in the last few years. The graduate level computer graphics program for artists at The Ohio State University has existed for ten years as a result of the pioneering effort which Charles Csuri began in 1965. This fact makes the program at Ohio

State a good candidate to examine for possible curriculum directions in computer graphics. Other programs in computer graphics for artists are currently being proposed at: the University of Oregon, Nothern Illinois University, Rhode Island School of Design, University of Cincinnati, and MIT. These proposals as well as programs in existence are examined later in this document. These institutions have decided to invest in the future of computer graphics technology for artists and designers.

Computer graphics is becoming cost efficient since the price of hardware is constantly being improved while the machines are becoming faster, making it possible for institutions to begin programs for artists. The cost effectiveness of computer graphics is improving at such a rate that in the near future artists will be able to afford a simple system of their own. The growth rate of computer graphics is expected to stay between 27 to 37 percent per year over the next five years.

> The consumer sector, which includes video games and CRT peripherals for personal computers, is estimated to be at $2.6 billion for 1985 and expected to grow at a 30-percent rate over the next five years....The number of personal-computer users making use of computer graphics applications is expected to reach 10 million by 1989 [22].

Patrice Wagner [31] in an article entitled Computer Graphics in Higher Education surveys colleges and universities that offer courses in computer graphics. She states that:

> Much has changed since CGW took its first look at computer graphics in higher education a year ago. We have witnessed a proliferation pf programs and a continued interest on the part of many vendors in donating equipment to educational institutions....Students and professionals keep clamoring for courses in computer graphics, yet educators are often not equipped to set up programs to facilitate their needs.

Computer graphics is thought to be rather good in its image rendering capabilities but many improvements in rendererring the "real world" are anticipated. Ware Myers's article [22] Computer Graphics: The Next 20 Years:

> Henry Fuchs of the University of North Carolina...suggested that what we want is the ultimate display. "In the ultimate display you could sit on the computer generated chair...but I don't propose to tell you how we can solve that problem right now. What I do propose is that we can solve the visual end of it in the 20-year time frame. I believe that we will be able to generate images so realistically and bring them to the user so conveniently that to all intent and purposes he will interact visually with those images in the same way that he interacts with real objects in a room."

This illustrates that computer graphics is really in its infancy and will change a great deal in the next 20 years. Many conventions that are understood and accepted today will be altered or completely changed in the growth years to follow. Our computer will become smaller and faster, working in ways we have yet to imagine. These projections give some indication of the degree of flexibility and evolutionary outlook a program in computer graphics needs to anticipate in order to participate in this technology. The design of a curriculum in computer graphics needs to take into account the evolutionary nature of computer graphics and make provisions for the adjustment of the program's course structure to stay abreast of the changes. Individuals which desire to work in computer graphics must also be able to adapt to the changes that arise because of the developmental growth of this field.

The choice of a curriculum orientation for computer graphics will need to be done keeping in mind the evolutionary nature of computer graphics. There are many types of curriculum orientation: behavior, subject/disciplines, social, developmental, cognitive process, humanistic, and holistic. These orientations to

curricula will be reviewed in detail along with a proposed orientation for the development of a curriculum in computer graphics in the chapters to follow.

Chapter Two reviews computer graphics programs for artists that are in existence or are proposed. Chapter Three analyzes curriculum orientations, details the orientation or orientations proposed for curriculum development in computer graphics and the necessary ideas, objectives and concerns of a computer graphics curriculum. Chapter Four Chapter Five concludes with implications and recommendations relative to further research directions of computer graphics programs and curriculum development.

CHAPTER 2

Review of Computer Graphics Programs

2.1. Introduction

This chapter reviews five computer graphics programs developed for artists and designers. Some of these programs are currently in existence, others are being implemented, and some are being proposed. It is anticipated that an examination of these programs will aid in the development of a generalized curriculum model. The five institutions that will be reviewed are: Sheridan College in Canada, The Rhode Island School of Design, The University of Oregon, Northern Illinois University, and The Ohio State University.

2.2. Sheridan College Computer Graphics Lab

Sheridan College is a Canadian funded institution that enrolls over 6,000 students of which 1,200 are in two and three year programs in graphic design, photography, illustration and animation. Sheridan College has made a commitment to the application of high technology in

education. Educators at Sheridan recognized the necessity to establish a computer graphics laboratory and did so over four years ago. The fundamental rational at Sheridan is to offer individuals critical and interdependent characteristics through computer graphics. These characteristics are as follows.

> First, it should be interdisciplinary because the field covers so many specialties within the visual arts. Second, it should have an evolutionary structure because of the need to respond to rapid changes in technology and organizational structure. Third, it should facilitate maximum interactivity among faculty, staff and students. Fourth, it should have a professional applications orientation in keeping with the general philosophy of the school. And fifth, it should maximize and encourage creative behavior [12].

2.2.1. Philosophy

The philosophy, structure and curriculum of Sheridan College stresses visual problem-solving and design methodology, and an integration of four major aspects of creativity which includes selection of:

> ...creative individuals as students, staff and faculty; designing curricula which stress and support creative problem-solving processes; creating innovative and imaginative products; and developing a creative, flexible and evolutionary environment which functions as a catalyst [12].

2.2.2. Curriculum

The curriculum structure at Sheridan College is set up to promote visual problem solving. The program offers courses which help students develop skills in 2-D and 3-D computer graphics as well as computer animation. The courses are as follows.

2.2.2.1. Introduction to Computer Graphics This course reviews the computer's visual possibilities by explaining raster and vector displays, the frame buffer, input and output devices as well as the architecture and software characteristics of the computer.

2.2.2.2. Introduction to Programming aids the artist in the development of a working knowledge of programming. The purpose of this course is to facilitate a better working relationship between artists and programmers.

2.2.2.3. Design Application is a lab course which exposes the artist to various turn-key and developmental systems. Each student works with three systems of their choice which are best suited to their particular area of specialization. The student receives

"hands on" experience with a wide variety electronic and computer technology.

2.2.2.4. Concept Analysis is offered to develop and research ideas relative to three specific disciplines: Graphic Design from a problem-solving and visual idea perspective; Animation from a story boarding and animation dynamics perspective; and Creative Behavior from an analysis of complex systems perspective. A production seminar is held weekly to discuss research and development directions as well as offer an arena for critiques and exchange of ideas.

2.2.2.5. Computer-Aided Communication is a lecture series that covers many computer graphic topics and is presented by specialists in computer graphics.

2.2.3. Student Requirements

Applicants are required to have a minimum of four years of professional experience in design and/or art or be a graduate of a post-secondary art or design program of at least two years duration. In addition, applicants need to submit a portfolio of work to be reviewed by the

selection committee and a statement of intent which indicates an interest and proposed direction of study in computer graphics. Robin King [12] states that it is necessary to:

> Identify the cyberphobes ahead of time! Choose students with an experimental or applications orientation flare; as a rule, artistic and design experience is more crucial to success than computer literacy...

2.2.4. Concerns

A major problem at Sheridan College was the acquisition of sufficient financial backing. Sheridan College solved their financial problem for the present time by acquiring funds from with the institution and public funding through grants. Another major problem was the technological devastation students felt in the new environment. "This brought about a change in the emphasis from technology to a concentration on developing new techniques and strategies in design methodology." [12] Frustrations over the design of computer graphics software interfaces still proved to be a relevant issue.

2.3. Rhode Island School of Design

The Rhode Island School of Design (RISD) is a highly respected college which offers a total of seventeen programs that cover artistic activities from architecture and industrial design to sculpture, jewelry and photography. RISD's enrollment is kept at an optimal size of 1,700 students in order to promote high standards of quality. RISD has established a working relationship with Brown University to aid in the college's quest to implement computers in it's arts and design programs. This relationship is only one example of the innovative style which is supported from within as well as from outside the surrounding community. "While faithful to fundamental values that remain valid even in our days, the School continuously adapts to new demands." [23]

2.3.1. Philosophy

The philosophy behind the implementation of computers in the college of art and design at RISD:

> ...is to present a model for implementing computers and computer-related means of expression, representation and communication in an environment which, despite its potential, has been only particularly considered by the computer industry and the computer scientist [23].

RISD does not want to become a high tech institution. Rather, it has realised the need to integrate a plan with Brown University to develop complementary environments of learning. With this in mind RISD has committed to three relevant issues:

> 1. issues concerning computer use in the various design and art programs offered and dealing with the important question of art and design (and liberal arts) education in our time and in the foreseeable future;
> 2. issues of design for computers and their future improvement, especially in user interface, computer graphics, ergonomics, and industrial design;
> 3. issues concerning the design and production of computers and computer-supported equipment adapted to the various needs of design activities, with special emphasis on graphic design, architecture and art applications [23].

From these issues, it is apparent that RISD takes a broad perspective of the uses of computers by artists and designers. The school:

> ...interdisciplinary by the nature of its object of interest, is the common denominator among the highly varied programs and projects at RISD [23].

2.3.2. Curriculum

The curriculum structure proposed for RISD has a board focus from investigations into the capabilities of the computer and it's human interface to the development of computer literate and visually aware students. The curriculum is as follows.

2.3.2.1. Introduction to Microcomputer Programming centers on teaching students with little computer experience about the basic mechanical operations of computers and peripherals, hardware, applications and potentials, introduction to programming and basic software usage.

2.3.2.2. Software Application/Development:Microcomputers emphasis on independent study, research and development with available software and help establish direction and curriculum content within the department of architectural studies.

2.3.2.3. Survey of Computing offers a broad overview of the computer in other disciplines and computer literacy with hands-on experience.

2.3.2.4. Computer Graphics is a senior level course exploring relevant design problems in computer graphics technology.

2.3.2.5. Artificial Intelligence is an investigation into whether the question "do computers think?" can be answered and if so to what capacity.

2.3.2.6. Man-Machine Interface is concerned with the basic conceptual and technical tools of industrial design with a professionally-oriented approach.

2.3.2.7. Graduate ID Design III is a developmental course for research in the student's proposed thesis topic.

2.3.2.8. Visible Language explores visible language and it's function in communication design.

2.3.2.9. Modules and Grids offers collective research experience culminating in a major studio project which has a common design theme.

2.3.2.10. Charts and Diagrams is an investigation of visual systems which communicate information through a combination of notational, visual

and structural forms.

2.3.2.11. Critical Reasoning aids in the development of the visualization of the principles of deductive and inductive reasoning.

2.3.2.12. Intro to Micro-computers This course will introduce students to micro-computer hardware, operational procedures with various standard software packages and some basic programming procedures.

2.3.2.13. Micro-Computers and Professional Applications emphasizes hands-on experience with software packages most frequently used in professional applications: word processing, accounting and time management. Students are encouraged to do programming and investigate graphics applications.

2.3.2.14. Seminar: Micro-Computers fro Faculty/Staff This seminar is designed to introduce RISD faculty and staff to the potential applications of the micro-computer in their academic, personal and professional lives.

2.3.3. Student Requirements

The student requirements for entry into the Rhode Island School of Design are average testing scores on SAT and ACT scholastic test plus satisfactory proficiency in drawing. Other than these requirements, students must show a need for the use of the computer in their projects or be taking courses which require use of a computer.

2.3.4. Concerns

There are two major concerns over the use of computers at RISD:

> 1. How will design be changed as a result of the post-industrial revolution, primarily through the extensive use of computers?
> 2. How will design change the world as it influences both technology and human relations, especially in the environment of widespread computer-supported activities [23]?

The Rhode Island School of Design does not want to become a high tech institution and thus they have designed their proposal to be synchronized with some of the efforts Brown University has proposed to their System Development Foundation. In doing so, RISD attempts to complement rather than duplicate the available resources of computer

technology at Brown University. The overall direction relative to computer implementation at RISD is to interface the computer within the existing structure, offering computer time to students working in design, computer art, and students that need to use a computer to produce their projects. The computer is also proposed to be used to mechanize the Library and Museum facilities. In all, the computer would be applied to almost every possible area within the educational structure at RISD. Students are then given a chance to decide whether they want to use computer technology or not.

2.4. The University of Oregon

The University of Oregon is a state supported institution which has been involved with computer graphics for a number of years. The Departments of computer science, mathematics, psychology, physics, art, architecture, and design are currently engaged in some degree of computer graphics activity. A proposal with a more focused direction in computer graphics has been developed and is expected to be implemented in the near future. The University has held the Northwest Computer

Graphics Conference for three years which has helped in the University's desire to become a leader in the computer graphic's field.

> This year, in the Architecture and Allied Arts School alone, some 300 to 400 students are enrolled in computer graphics courses. The UO Continuation Center also offers computer applications courses for the general public, including one on computer graphics [7].

As another testament of involvement in computer graphics at the University of Oregon, the publication, The Computer Teacher and the International Council for Computers in Education are located on the campus.

2.4.1. Philosophy

The philosophy presented in the University of Oregon's proposal focus on the establishment of a interdisciplinary Masters of Science Degree in Computer Graphics under the School of Architecture and Allied Arts plus the establishment of a Computer Graphics Institute. The acquisition of traditional values, philosophy, and content of the School of Architecture and Allied Arts are to be the achievements of the Masters Degree. The Masters Degree should also incorporate:

> ...information from the field of computer science to the extent necessary for use of high-technology in the communication and inquiry of artists, environmental designers and art educators [5].

Each student's course of study is to be highly individualized and promote the development of visual skills, patterns of thinking and ways of working.

The Computer Graphics Institute is to research the nature of computer graphics while promoting the sharing of resources through out the university. In addition to this, the Institute is to aid in the education of students and faculty, industry and the community plus be a service to the community. The philosophy thus is to have two separate units that mutually support each other while having two basically different missions.

2.4.2. Curriculum

The program at the University of Oregon is presently being proposed, thus only some of the courses are described in the following outline of courses.

---Core Courses---

2.4.2.1. Microcomputers and the Design Process introduces the terminology of small computer systems, their operation, and their applications for artists and architects. A variety of computer programs are reviewed and demonstrated.

2.4.2.2. Communication Graphics introduces the design process which are needed for the development of computer graphics. Topics covered are: perception, design principles, human response and functional aspects of design; layouts and grids; introduction of type; use of images and words; visual communication and organization of information.

2.4.2.3. Techniques of Programming Graphics is concerned with the programming of apple computers to create a variety of visual effects for graphics design purposes. The development of a working knowledge of the PASCAL programming language.

2.4.2.4. Computer Imagery in Art and Design: History

This slide/lecture course examines the evolution of computer imagery in the fields of art and design. The people, places, and processes relative to computer graphics are explored.

2.4.2.5. Research Methods Computer graphics in the visual arts, environmental design, and art education and the fundamental methodologies of scientific inquiry relative in each of these areas are studied with attention to their application to research in computer graphics in art and design. Emphasis is on research proposals and critique of the reports.

2.4.2.6. Contemporary Issues The exact description has not been outlined.

2.4.2.7. Concentration Areas The student is to select in consultation with the program adviser an area of study in the arts. The courses may not all come from the School of Architecture and Allied Arts. The majority of hours and major interest are within this area.

2.4.2.8. Internship The exact description has not been outlined although it is indicated that the students will need to write a proposal for the internship work and submit a final report to the program adviser.

2.4.2.9. Terminal Project/Thesis The exact description is not available but the thesis topic is to be related to the Internship experience and to the selected concentration area.

2.4.3. Student Requirements

The only requirement of students presently is that they have an undergraduate degree.

2.4.4. Concerns

The University of Oregon needs to compliment the current user approach by an emphasis on programming in the lower course levels. Other recommendations are the need to raise the admission standard to include only student with an arts degrees with in emphasis on the visual arts. The structure of the proposed Masters of Science Degree in Computer Graphics enables students to design their own course structure, giving students choices as to the amount and degree of computer instruction desired. The inclusion of the Computer Graphics Institute enables the research activities to go on in computer graphics technology while offering a window of information to society and industry.

2.5. Northern Illinois University

Nothern Illinois University (NIU) is a state supported institution with a total enrollment of 24,000 with 2,500 students in the College of Visual and Performing Arts. NIU has been actively involved with electronic media for a number of years, making a tentative commitment in this area. From this experience, NIU has investigated the possibilities of computer graphics and electronic media, and has decided to make a major commitment by establishing the Electronic Media Laboratory. The information that follows has been attained from the proposal of an Electronic Media Laboratory in the College of Visual and Performing Arts.

2.5.1. Philosophy

The philosophy behind the proposal of an Electronic Media Labortory (EML) is "...to develop a college-wide facility open to all the Visual and Performing Arts faculty and students." [14] The implementation of the EML is divided into two phases with the first phase concerned with the concepts:

1) To achieve a level at or near state-of-the-art technology 2) To maximize versatility. And 3) to

be as cost effective as possible [14].

To be as cost effective as possible the EML needed to consider the present hardware and software and use this technology in the best interest of the lab. The second phase of the EML is:

> ...to be comprised of hardware for advanced video, electronic music composition and several graphics workstation configurations: minicomputer or mainframe system, very large disk storage capacity, 24 bit frame buffer and very high resolution display capabilities. A true UNIX/ C environment [14].

The philosophy behind the EML is further explained in the use of the term "media and technology" which is defined by Kolomyjec [14] to be:

> ...imagery or objects that are produced using technology...slide and movie projection systems, equipment to control slide and movie projection systems, analog and digital video, analog and digital video editing and projection equipment, computer graphics hardware and software, computer image editing and projection systems, and any combination or permutation of these.

2.5.2. Curriculum

We are unable to list all of the courses that pertain to the B.F.A. degree offered at NIU, since the degree is a

comprehensive design-electronic media alternative and thus prove too lengthy. The following courses are offered through the Electronic Media Laboratory.

2.5.2.1. Fundamentals of Computer Graphics is an introduction to the basics of computer-aided design including data generation and manipulation techniques.

2.5.2.2. Introduction to Intermedia Arts introduces the student to concepts and techniques of interrelating various arts, emphasizeing computer slide programming, media performance art, and multimedia.

2.5.2.3. Introduction to Video Art pertains to concepts and techniques of video art.

2.5.2.4. Studies in Motion Graphics is the development of electronic media involving animation and motion graphics. This course is repeatable to a maximum of 9 hours.

2.5.2.5. Media Graphics investigates the usage of tradition techniques of graphic design as well as software and electronic media to produce effects and action titles for educational and commercial television graphics.

2.5.2.6. Electronic Media Design deals with problems in design and layout using computers.(Repeatable to 6 hours.)

2.5.2.7. Media Synthesis researches the validity of combining and integrating a variety of electronic media. (Repeatable to 9 hours.)

2.5.2.8. Computer Graphics is a study of advanced concepts for programming aesthetic two- and three-dimensional computer graphics on microcomputers, emphasising data construction and algorithmic imagery.

2.5.3. Student Requirements

Written approval from the electronic media faculty is needed to permit students to declare a major in the comprehensive design-electronic media alternative; plus a portfolio review after some initial course work in the EML; a GPA of 3.2 in their major area; and review of studio performance during each spring semester for retention in the student's major area of interest.

2.5.4. Concerns

The program is set up as a B.F.A. degree that "is intended primarily as preparation for advanced study at the graduate level in electronic media, photography and/or other areas of design specialization." [14] The fact that electronic media relative to computer graphics is so new suggests there is a need for students and faculty with expertise in this area which implies that a major focus should be made. As it is, the program offers a taste of "media and technology", anticipating graduate enrollment. If this is the case then a major in "media and technology" should be declared at the graduate level. The proposal seems to offer an interesting mix but does not train the student in the specifics of electronic media and computer graphics. There is a need for a major in "media and technology" to supply society with experts as well as to train educators in the practical and conceptual aspects of "media and technology".

2.6. The Ohio State University

The Ohio State University is a land grant, state supported institution with an enrollment of more than 50,000 students. The Computer Graphics Research Group (CGRG) is a research facility which brings together computer programmers and artists and is located in the College of the Arts. The CGRG is an interdisciplinary unit with students, staff, and faculty from the Departments of Electrical Engineering, Computer and Information Science and Art Education. Total involvement at the CGRG ranges from 45 to 55 students with a faculty of five having joint appointments in other colleges within the university with four support staff positions as well. Funding for the CGRG comes from the university, the National Science Foundation and a variety of research contracts. "For ten years, the program at Ohio State has offered entrance to the high-technology field of computer graphics through the arts and education." [16]

2.6.1. Philosophy

The philosophy of the Computer Graphics Research Group has been to provide:

> ...both research and instructional opportunities for faculty and students interested in aesthetic and educational applications. The commitment to

> this direction provides a basic philosophical orientation to the current instructional practice and has attracted national and international attention [16].

The main focus within this philosophy is the investigation of three dimensional space through animation. This approach tends to be relatively specific in that it pertains mostly to 3D computer animation and yet it is very broad since 3D computer animation is really a simulation of our "real world." The present philosophy is to develop a sound graduate program and use this program to aid in the development of an undergraduate program.

2.6.2. Curriculum

The main focus of the CGRG's curriculum in computer graphics is toward graduate level courses. A few undergraduate courses are offered as follows:

---Undergraduate Courses---

2.6.2.1. The Arts, Education, and Computer Technology

reviews the history of computer graphics animation and its applications through the use of videotapes and discussions.

2.6.2.2. Microcomputer Graphics in the Arts and Education provides hands-on experience with graphics/animation while encouraging students to seek applications of micrographics in their area of interest.

---Graduate Courses---

2.6.2.3. Computer Graphics/Animation: Application in the Arts and Education presents key technical, aesthetic, and educational issues relative to computer graphics.

2.6.2.4. Computer Graphics/Animation Production I introduces the student to 3D computer animation and basic data generation. A short animation is completed on the DEC 1173 computer.

2.6.2.5. Computer Graphics/Animation Production II continues with more dynamic 3D computer animation and data generation. An animation is produced on the SUN workstation.

2.6.2.6. Computer Graphics/Animation Production III combines the previous knowledge of computer animation in the production of an extended animation segment on the VAX 11/780.

2.6.2.7. Street Math for Artists reviews college algebra from a visual geometric perspective which directly relates to the mathematical principles used in computer graphics and animation. It surveys solutions to systems of equations, trigonometry, cartesian coordinate, equations of motion, functions, and analytic geometry.

2.6.2.8. C Programming in an introduction to the C programming language.

2.6.2.9. Digital Image Criticism introduces a variety of critical systems derived from traditional film and photography and applied to computer imagery. The aesthetics of computer graphics are examined and questioned.

2.6.2.10. Traditional Animation analysis of traditional animation techniques from Disney Studios, Warner Brothers, and Eastern Europe as a lead-in to 3D computer animation studies.

2.6.3. Student Requirements

Students are required to have a baccalaureate degree in an arts related field; a minimum GPA of 2.7; a portfolio review; an interview with computer graphics

faculty members; a "Statement of Intent" for graduate study; three letters of recommendation; plus the requirement of two basic level programming courses.

2.6.4. Concerns

Some concerns have been expressed relative to the interaction of students with diverse backgrounds in a research environment. Problems can and do arise as a result of the mixing of diverse student backgrounds.

> When twelve people are, at times, forced to use one system due to any number of disastrous situations, they'd better be able to get along. This means that the program administrator must go out of his/her own way to facilitate a friendly working environment and maximize avenues of communication...Artists should not be isolated from computer programmers or system people and vice versa. Interaction should be encouraged [13].

Another concern is that the CGRG is relatively autonomous with respect to the university as a whole. This problem is considered in a proposal to establish an Advanced Computer Center for the Arts and Design. The proposal states it's purposes as:

> 1. To apply advances in computer technology to the processes, values, and ideals of the arts.
> 2. To promote interdisciplinary projects and programs with visual and performing artists,

> designers, art historians and critics; and with computer scientists, engineers, and mathematicians.
> 3. To employ sophisticated computer technology for investigation of artistic production and for evaluation and modes of dissemination [17].

The proposal designates the assumption of both the current purposes and programs of the CGRG while promoting the interdisciplinary nature of computer graphics. Another concern is relative to the artistic environment at the CGRG. The question can be raised as to whether this environment is conducive to both research and artistic activity.

CHAPTER 3

Analysis of Curricula

3.1. Introduction

This chapter begins by defining various curriculum orientations. With the definitions in mind, each of the institutions of higher learning reviewed in Chapter Two will be viewed in relationship to one or more of the curriculum orientations. This is done in an attempt to determine the curriculum structures that other institutions have used. Next, a recommendation will be made as to which orientation(s) should be considered for a computer graphics curriculum. With this information in mind, the students', the institution's, and society's interests will be taken into account in order to establish some basic concerns which must be considered when developing a computer graphics program.

3.2. Curriculum Orientations

This section offers a short analysis of some of the more important curriculum orientations. It is anticipated that through the analysis, we can come to a better understanding of curriculum types and the difficulty of designing a curriculum in general and a computer graphics curriculum in particular.

3.2.1. The Behavioral Orientation

The Behavioral Orientation is concerned with shaping specific student behavior (i.e. stimulus/response). Within the Behavioral Orientation are the operant coding which intends to shape desirable behavior while reducing undesirable behavior, and competency-based education which aims to develop the cognitive, the affective, and the psychomotor domains of students. It is argued that the Behavioral Orientation enhances communication, helps to plan curriculum, aids in the school's efficiency, individualizes instruction, and improves evaluation. The negative side of the Behavioral Orientation is that: it is difficult to reduce activities to specific behavioral terms; it is easy to lose sight of human goals; it can hinder instructors' flexibility and creativity; it does

not encourage risk-taking and intuitive hunches; and the list of behavioral objectives can become very lengthy and unusable.

> Behavioral objectives can have a place in the overall curriculum. However, it makes more sense that their place be limited to those portions of curriculum where they are appropriate, rather than reducing all aspects of the curriculum to behavioral terms [20].

3.2.2. The Subject/Disciplines Orientation

The Subject/Disciplines Orientation centers on subject and academic disciplines. This curriculum orientation was employed in the 1960's in an attempt to teach science and mathematical properties to students. It was to prepare students for the space race which the Russians had initiated with the launching of Sputnik in 1957. The main focus of instruction was on discovery of scientific and mathematical concepts. The traditional subject areas of math, science, English, history, and a language were usually the focus in secondary school. The conceptual framework and methods of inquiry of disciplines were also to be attained in higher education. Today the Subject/Disciplines Orientation, known also as the back-to-basics movement, is being revived by some

institutions [20,19].

> For example, in 1982, Harvard University implemented a new undergraduate core curriculum designed to bring purpose and coherence to courses of study. This curriculum requires students to meet academic requirements in five areas: literature and the arts, history, social analysis and moral reasoning, science, and foreign cultures....It requires also that students show proficiency in writing, mathematics, and the use of computers [20].

The Subject/Disciplines Orientation has a number of disadvantages. This orientation tends to be directed toward specialization in subject matter, making it difficult for students to see relationships between other subjects. Also, this orientation tends to impose adult views of subject matter on students making courses more applicable to college-bound students. Another criticism of this orientation is that it tends to center too much on lower levels of learning, focusing on information recall and basic skills with little development of higher-order analytic and conceptual skills.

Arguments in support of the Subject/Disciplines Orientation are: it organizes the curriculum in a systematic way; it is efficient to use and easy to administer; it relates well to texts, since they are

subject oriented as well; and it has a tradition that continues in most institutions. Tanner and Tanner [30] noted that a study reported by the Harvard Project Physis indicated that:

> ...teacher personality and student attitudes and interest are much more potent predictors of pupil achievement than the extent of the teachers' specialized study of physics.

In a report supported by the National Science Foundation, a group of curriculum experts were given the task of developing a new approach to science education. These experts concluded that:

> ...the present curriculum is organized around the structure of separate disciplines, with only marginal emphasis being given to social problems or personal application to knowledge...the life science curriculum of the future will be organized around the theme of human adaptation in both scientific and social senses and that the use of biological knowledge in making decisions will be an important goal along with values and ethics [19].

These two reports point toward a Subject/Disciplines Orientation having more humanistic student-faculty interaction while developing an understanding of the relationships between disciplines.

3.2.3. The Social Orientation

The Social Orientation in concerned with the improvement of society by: teaching students appropriate social values and to meet various role expectations; assisting the student in developing skills to analyze value conflicts and make decisions within a democratic context; and examining real situations and becoming actively involved in social change in the school and the community [20,19]. Efforts to use the Social Orientation have chiefly been in poor communities and the Third World countries although "it has been suggested that such programs as vocational education, career education, and work-study programs as well as behavioristic programs fit into the cultural transmission mode." [20]

The problem with the Social Orientation is that: it is difficult to agree on what conduct is best for planning and achieving social change; it forces students to function within the constraints of society; and it is difficult to implement in schools that deem it necessary to keep a close account of students. The positive side of this orientation is that: it can aid in the understanding of problems facing society such as famine, inflation,

national debt, and pollution; and it can help convince students that they are able to bring about changes within the school setting and society.

3.2.4. The Developmental Orientation

The Developmental Orientation is concerned with the developmental stages of students, attempting to maximize the student's learning at the various developmental stages.

> ...the learning environment should be designed to facilitate growth so that development is not arrested or retarded at any stage...so that cognitive, moral, and ego development are interrelated and one aspect of development (e.g., cognitive) does not outstrip the other aspects [20].

The developmental psychologists who have been central to defining this perspective are Jean Piaget, Erik Erikson, and Lawrence Kohlberg. Piaget and Kohlberg, more concerned with the cognitive developmental framework, have focused on the structure of reasoning, while Erikson, more concerned with the psychosocial perspective, has focused on specific psychosocial concerns. Each of these developmental psychologist are concerned with the individual's cognitive, emotional, and moral development from infancy through adolescence to early, middle, and

late adulthood. This orientation attempts to match learning opportunities with the student's thought structure [19,20].

The Developmental Orientation is criticized for it's lack of precise curriculum construction and the lack of a means of measurement of individual's developmental stages across the scope of subjects. It is also difficult to determine each student's stage and relate that stage to each student in a large group. The positive side of the Developmental Orientation is that students are able to learn at the speed that is best suited to their developmental stage.

3.2.5. The Cognitive Process Orientation

The Cognitive Process Orientation is interested in how individuals think, how thinking occurs, and the development of curriculum programs designed to stimulate cognitive processes. A number of approaches have been developed which are distinguished by their modes of thinking (i.e., inductive, deductive, vertical and lateral). Inductive thinking, according to Hilda Taba, helps students develop concepts when responding to questions which require them:

> (1) to enumerate items; (2) to find a basis for grouping items that are similar in some respect; (3) to identify the common characteristics of items in a group; (4) to label the groups; and (5) to subsume items that they enumerated under those labels [29].

This manner of thinking permits students to interact with information and draw conclusions, generalities, and concepts from there interaction. Other structures include problem solving and thinking games designed to encourage students to make inferences of their own through sequential thinking. This mode of thinking in classed as vertical thinking which includes inductive and deductive thinking. Another mode of thinking is lateral thinking which De Bono [3] states is: "The most basic principal of lateral thinking is that any particular way of looking at things is only from among many other possible ways." He also says that vertical and lateral thinking are complementary with lateral thinking being a more deliberate process but similar to insight, creativity, and humor. Miller offer more insight into the differences between vertical and lateral thinking:

> Vertical thinking is sequential while lateral thinking can make jumps...the person jumps around and then fills in the gaps afterwards....In vertical thinking one closely follows every step or chaos can result. In lateral thinking the indivi-

> dual does not have to be correct at every step....In lateral thinking there is the risk that there may be no solution, although there is the possibility that a more comprehensive solution will be reached [20].

Implementing a Cognitive Process Orientation may cause problems. If students are taught thinking skills then much of what is established may be questioned. This might cause a disruption within schools if the students believe that they have better solutions to the operational problems of the school. Also, if instructors:

> ...are to teach thinking, then they need extensive training in observing children's thinking, developing programs based on cognitive processes, and implementing these programs in the classroom. Training teachers would require a major shift in emphasis from the traditional focus on traditional subject areas [20].

It also seems that at some time in the development of thoughts, the problem solving process needs to be related to specific cases in order to permit students to see the value and relevance of their thinking.

3.2.6. The Humanistic Orientation

The Humanistic Orientation attempt to provide students with experiences which contributes to personal liberation and development. Such words as empathy,

genuineness, and respect are used to describe the self-actualization of individuals. It is believed that:

> ...individuals have within themselves vast resources for self-understanding and for altering their self-concepts, basic attitudes, and self-directed behavior; these resources can be tapped if a definable climate of facilitative psychological attitudes can be provided [26].

This orientation teaches the student to be a fully functioning person in touch with his feelings and inner being in an open way. The main purpose of instructors is to "...be facilitators of learning...develop trusting and open classroom climate and then help students achieve their learning goals." [20]

This orientation has been used in encounter groups to encourage individuals to assert their selves. Critics of the Humanistic Orientation say that if a person has a choice as to participation then this orientation is fine. They disagree with it's use in public education since student could not be given this choice. Besides being difficult to evaluate student progress, there is a lack of evidence supporting the use of the Humanistic Orientation. Critics also say that this orientation is too self centered, implying that a curriculum needs to be more

concerned with social change. Others say that the Humanistic Orientation would be greatly improved if it included some relation to the environment [19,20].

3.2.7. The Transpersonal Orientation

The Transpersonal Orientation, known also as the Holistic Orientation, builds upon the positive self-concept of the Humanistic Orientation by including the use of intuition to access creative thinking and holistic perception. This orientation seeks to bring about a balance between analytic thinking and intuitive thinking. Much of the theory is based on brain research which has determined that the left hemisphere is specialized in analytic thinking with the right hemisphere reserved for artistic endeavors, spatial orientation, crafts, and recognition of faces (i.e., intuitive processes).

> Intuition and imagery are central to a transpersonal perspective because of the tendency of intuition to perceive similarities between phenomena rather than differences. In short, intuition allows the person to see connections between phenomena rather than differences. When left brain thinking is predominant, we tend to focus on differences and single out specific events; when intuition is predominant there is a tendency to see things as part of a whole. Intuition, according to transpersonal educators, allows us to see the oneness behind all phenomena [20].

In creative thinking, imagery is often associated with intuitive insight. Individuals gather information relative to a problem and are not concerned with solving the problem at that particular moment. We have all said at one time or another that "I'll sleep on it" or "Maybe it will just come to me." The relaxation of conscious effort permits the brain to process or incubate the given information. Then, as we are working or viewing something else, an answer appears in our mind quite unexpectedly.

A number of scientists have experienced such illumination and acknowledge the importance of intuition. Based on picturing himself on a ray of light, Einstein discovered the principle of relativity. While quoting poetry to a friend and walking toward the sunset, Nikola Tesla, had an illuminating experience which resulted in the discovery of the rotating magnetic fields use in alternating electric current [20]. The Transpersonal Orientation is concerned with the oneness of things similar to Zen and other Easter philosophys. This orientation attempts to set up a structure for self discovery; respecting life, death, learning, growth, family, the arts, religion, and the community, in essence, a respect for all things, ideas and relationships.

Education is then seen as a life long ambition since the world is in constant flux and thus, development of a oneness with the world needs to deal with the dynamics of reality. Miller states that:

> ...the impact of this orientation is currently very limited. The emphasis on transcendence and spirituality is counter to the traditional thrust of public schooling. There is also the danger of transpersonal quackery where pseudo-gurus intermingle with those that are genuinely seeking spiritual meaning....The future of the transpersonal orientation, then, is allied to a larger cultural movement. How successful this movement is, and how intelligently it responds to many of the problems that are impinging on society, will determine in large how influential the transpersonal orientation is in the coming decades [20].

3.2.8. The Technological Orientation

The Technological Orientation uses technology to aid in the instruction of students. This orientation is of importance today because of the computer and it's interactive capability. Many universities use sophisticated electronic devices such as video and audio cassettes and computers to transmit some portion of their curriculum to students much in the tradition of the Behavioral Orientation.

Applied technology is a plan for the systematic

> use of various devices and media or a contrived sequence of instruction based on principal from behavior science. Computer assisted instruction, systems approaches using objectives, programmed materials, tutors following scripts aimed at teaching a specific skill, and criterion-referenced tests are all examples of applied technology. A defining element of technology is that its systems and products can be replicated [19].

Some proposed advantages of the computer assisted instruction are that the learner works one to one with the computer permitting students to learn at their pace and degree of interactivity. Edmond Gordon professes that:

> ...the tightly structured programmed approach including frequent and immediate feedback to the pupil, combined with a tutorial relationship, individual pacing, and somewhat individualized programming are positively associated with accelerated pupil achievement [6].

A number of concerns have surfaced over the use of computer assisted instruction. First, learning levels and prerequisites have not been very well defined by designers of instructional material. Students do well on the specific questions that are examined in the instructional package but have trouble relating the ideas past this specific level. Second, this mode of instruction is only useful for instruction of subject having procedural structures which can be broken down into separate steps

taken to accomplish the task. Art, critique writing, and decision making are difficult to break down into separately teachable tasks. Third, technologist have not taken into account students' different learning aptitude levels. Students of low aptitude might do well with a particular instructional package while student of high aptitude might be frustrated by the same instructional package. Possibly, development of a number of instructional packages dealing with the same subject but with more emphasis on the conceptual thinking would solve this problem.

> In Mindstorms: Children, Computers and Powerful Ideas, Seymour Paper offers a fresh alternative in the technological curriculum. Paper arranges the computer so that young people learn to control, not be dominated by , their technological environment. To him, the computer is a vehicle for Piagetian learning by which children are encouraged to integrate new concepts into their existing repertoires as they manipulate objects defined as figures on an interactive computer display [19].

Thus, students are able to take new information and process it in a manner suitable to their learning methods.

3.3. Existing Computer Graphics Curricula

Taking a look at the curriculum structures and philosophys of the Computer Graphics programs outlined in Chapter Two can aid in the development of a usable curriculum orientation for computer graphics. Sheridan College uses interdisciplinary, evolutionary, interactivity of students, staff, and faculty, professional orientation, and encouragement of creative behavior to describe necessary ingredients for the development of a computer graphics curriculum. To do this, a creative, flexible and evolutionary environment which stresses creative problem solving needs to exist. We are hard pressed to place this curriculum into one of the curriculum orientations previously described. Sheridan College's curriculum structure has elements of the Transpersonal Orientation, the Humanistic Orientation, the Cognitive Process Orientation, the Social Orientation, and the Subject/Disciplines Orientation. The curriculum structure at The Rhode Island School of Design uses the computer as a unifying device for the interdisciplinary investigation of art and design, issues relative to human interfaces and ergonomics, the interrelatedness of visual language and critical thinking. The RISD curriculum,

although concerned with the attributes of most of the curriculum orientations, leans toward the Cognitive Process Orientation, the Social Orientation, and the Subject/Disciplines Orientation.

The University of Oregon, realizing the interdisciplinary nature of computer graphics, has designed it's curriculum about the integration of students in a Master's program with a Computer Graphics Institute developed to educate student and faculty, industry and the community as well as perform research in computer graphics. Again, many of the discussed curriculum orientations are integrated within this program.

The program at Northern Illinois University is also concerned with being a college-wide facility and is recognizes the interdisciplinary nature of computer graphics and electronic media.

The curriculum structure of the Computer Graphics Research Group at The Ohio State University, although it has been intardisciplinary to some degree, is to become more interdisciplinary in nature. The program also has a flexibility which permits it to adapt to changes relatively easy.

The interdisciplinary nature of these computer graphics programs speaks also of their orientation to curricula. They all tend to have a number of elements of many of the discussed orientations in their structures. The point here is that a computer graphics curriculum need not be limited to a particular curriculum orientation, rather choosing the strongest and most usable concepts of a number of orientations may be more appropriate. Instructors and curriculum designers need to be aware of the various curriculum orientations so they are able to select the orientations and methods most appropriate to their situation. Bruce Joyce in an article entitled Learning How to Learn explains that students need a mix of all the curriculum orientations.

> Whereas debates about educational methods have seemed to imply that schools and teachers should choose one approach or another, students need growth in all areas. To tend to the personal but not the social, or the informal but not the personal, and so on, simply does not make sense in the life of the growing student...growth in teaching is the increasing mastery of a variety of models of teaching and the ability to use them effectively [11].

3.4. Recommendations for a Computer Graphics Curriculum

Some examples of existing curriculum structures were given in the previous sections that can be used in the development of a computer graphics curriculum. Since computer graphics for artists is so new, a certain flexibility needs to exist to adjust and improve the modes of thinking and teaching (i.e., the curriculum needs to have an evolutionary nature). This relates to what types of courses are taught as well as the concepts covered within a course.

Students also need to have an evolutionary nature. Computer graphics can be very disorienting for students when faced with the latest computer designs and all the "bugs" which are part of a development process. At times, concepts that worked with the old technology need to be altered or completely forgotten to function with the newer technology. This illustrates why a curriculum in computer graphics needs to have a humanistic nature sensitive to student's problems and flexible enought to adapt to each student's functional intelligence.

Much of computer graphics, a visual medium, needs to be taught through discovery, permitting the student to learn conventions relative to their modes of synthesis and visualization. For example, to understand 3D computer graphic's space, students need to have time to experiment with the computer's capabilities. They need to study what happens on the 2D display screen when objects are transformed. Some concepts (i.e., rotation by degrees) have a direct relationship to the real world manipulation of things, while other transformations, such as the movement of objects (there is no intrinsic scale of inches or centimeters within the computer) have no relationship to reality. Students need to be able to absorb these properties of 3D graphics into their modes of learning. Assigning specific problems to be solved by students can help reinforce their understanding of computer graphics concepts. For example, asking students to express the weight of an object within an animation helps students increase their understanding of computer graphic's properties.

Many of the ideas relative to curriculum theory are pertinent to it's interpretation within an educational environment. James B. MacDonald in an article entitled How

Literal is Curriculum Theory states that there are basically two approaches to curriculum theory; the simple minded approach and the muddle-headed approach.

> ...we might say that simple-minded, literal approaches to theory tend to claim scientific and/or technical status and are focused almost entirely upon instrumental purposes such as production, explanation, and control. The muddle-headed approach, metaphysical approaches, on the other hand, tend to be holistic, philosophical, and poetic and are focused upon expressive purposes leading to constantly revising phenomena to create new interpretations and greater understanding [18].

The muddle-headed approach to theory has many of the characteristics of the Transpersonal and the Cognitive Process Orientations which seem appropriate to a computer graphics curriculum. These orientations are concerned with independent thinking and concepts which illustrate the interrelatedness of things, making them appropriate conceptually for the development of new approaches to creativity in a computer graphics curriculum for artists.

3.5. Concerns Relative to a Computer Graphics Curriculum

Hilda Taba [29] in Curriculum Development: Theory and Practice points out that the three variables affecting the functional intelligence of students are native potential, motivation, and the environmental stimulus.

3.5.1. Native Potential

Native potential is the basic equivalent of the ability to learn and to reason [29]. One prerequisite of artists desiring to learn about computer graphics is that they need to have a degree of native potential which permits them to adapt to new situations. For example, they will need to be able to re-kindle their knowledge of mathematics as well as to deal with situations that require them to re-learn ways of doing thing that worked yesterday but, because of a program change, will not work today. Changes are the norm in a computer graphics program and artists will need to repeatedly re-learn concepts to keep from being frustrated by these events.

3.5.2. Motivation

Motivation, per se, is usually no problem in a computer graphics program since the medium is a high paced, flashy, and exciting field. Some unforseen

problems can arise.

> The function of intelligence can be hampered by many personal conditions, such as refusal to renounce dependency needs on a passive rather than aggressive orientation toward experience. Intelligence is hampered also by feelings which have an erosive or a tunnel-vision effect on perception, such as fear and anxiety. Persons subjected to these feelings for prolonged periods of time fail to develop their potential to learn, hence their potential to reason, hence also their cognitive functioning [29].

For example, for artists to do certain effects in computer graphics, they may have to seek help from more technically oriented students such as computer programmers or electrical engineers. This may prove to be a very demoralizing and intimidating experience causing much anxiety. Also, artists tend to be outspoken individuals when it comes to their art experiences. These types of activities can be taken very personally, and thus cause undue anxiety and frustration. The result may be that an artist feels unmotivated by the intimidation of others as well as by the technology.

On the other hand, the student-student interactions can be very supportive to learning and the development of modes of thinking. In a probe to determine why Yale has a notable reputation for training artists,

> ...art historian and Yale alumnus Irving Sandler mounted an exposition in 1981 called 20 Artist: Yale School of Art 1950-1970, for which he interviewed former Yale students at length. He notes that most of them mentioned the intense interaction -- between teachers and students, but especially among students themselves [15].

In an article titled Student-Student Interaction: The Neglected Variable In Education, David Johnson explains that there are a number of discrepancies between current educational practice and knowledge.

> The first discrepancy is that teacher-student interaction is emphasized and the possibility of student-student interaction is eliminated in many classrooms while it is the student-student interaction that may be the more important determinant of educational success. The second discrepancy is that competition and individualistic learning dominate most American classrooms, while cooperative learning experiences appear to be far more effective in promoting desired educational outcomes [10].

These findings indicate that student-student interaction and cooperation may prove to be a very desirable manner for artists to be educated.

3.5.3. The Environmental Stimulus

An individuals culture and environment have a lot of influence over their potential to learn since ones environment can affect their functional intelligence.

> Different persons may be subjected to different amounts of stimulation and to different content, depending on the culture in which they live. Primative people, whose culture lacks technology of any sort, are defective in technical reasoning or intelligence, not necessarily because their native potential does not allow it but because there is no environmental stimulation for its development [29].

Other examples are given, for example, when lower classes students are tested and compared to middle class students, the middle class students score higher. The lower scores of the lower class student are attributed to the lack of stimulation in their environment to preform well.

A computer graphics environment may also affect an artist's functional intelligence. Artists usually work in a studio environment which provides an individualized space for contemplation, visual problem solving, and experimentation. Computer graphics environments, because of the cost of frame buffers and display monitors, tend to have very few visual displays. This forces students to be in the same area sharing one or two displays for developing and designing the works of art. Artists, being natural critics, tend to offer suggestions as to how something should look or how "they" would do it, before the artist working on the image has a chance to test his

or her aesthetic ideas. Robin King of Sheridan College hits upon the problem when he states that:

> The physical environment can affect performance and psychological well-being, and we are still working on humanizing the environment and providing a sufficient variety of visual stimuli [12].

This problem is of major concern since there are many modes of artistic thought within a creative environment and each artist needs to be able to express his or her own. If a number of students are working on a project together then a space is needed for the group to develop their concepts together without input from others within the environment. Privacy to design, develop, test, and experiment with visual ideas is of importance and space needs to be allotted within a computer graphics environment to permit this flow of creativity. After artists' creative ideas have materialized, organized critiques can be offered as an arena for the exchange of conceptual and visual ideas as well as constructive criticism.

CHAPTER 4

Outline Of Curriculum and Program

4.1. Introduction

This chapter presents a discussion of philosophy, curriculum, student requirements, and concerns of a proposed Computer Graphics Program for the Arts. Some general topics are discussed at this point to help define problem areas and lay down a foundation for what follows.

Since many areas of interest are relative to the development of a Computer Graphics Program in the Arts, many issues need be considered at the very beginning.

4.1.1. Software Considerations

The initial choice of software must be done very carefully in order to guarantee that as many of the needs of faculty and students are met. The modes of operation and interaction with software; the capabilities relative to each discipline; the functional flexibility and programming viability; and the expandability of software should be weight when choosing software. Since software

development is usually done by scientists, the modes of operation of the software need to be tested to see if artists and designers can work with the software. The primary desires of architecture, design, and fine arts faculty relative to their specific discipline need to met. The software should be able to be used initially for functional and technical support of specific disciplines and have the flexibility of interfacing with special purpose programs written by students. The possibility of software up-grades needs to be considered as well.

4.1.2. Hardware Considerations

Considerations of cost effectiveness and flexibility need to be made to make certain that the best value as well as the degree of flexibility are attained in hardware. These considerations need to be made relative to processor word size (i.e. 32 bit, 16 bit and 8 bit) to make certain that the hardware will remain current plus offer the flexibility necessary to adapt to evolving technology. Presently a number of companys are offering computers with advanced price performance ratios by using the latest technological advances in computer chip design [21]. Although these machines are very desirable,

one must also consider the equipments flexibility, the company's maintenance support record, and its strength in the business world.

Assuming a variety of hardware levels are used in the computer graphics facility, hardware compatibility should be able to support the transfer of data between a number of machines. It is anticipated that the operating systems will be similar in operation if not identical. Also, the hardware should support the programming languages which the software uses.

4.1.3. Need for Artistic Investigation

Artists and designers need to examine the question of whether the present ways of working with a computer graphics program are best suited to their expressive needs, and if not, begin searching and developing improved ways of operation. Many research questions may be better suited to the intuitive and abstract thinking models which designers, architects, and artists use rather than the sequential and logical thinking of scientists. We are in a time when creative solutions to problems need to be investigated by the artist/designer and the scientist in order deal with many levels of complexity. One note should

be made, computer graphics is not the answer to all problems. It should be realized that computer graphics should be used to support technical and conceptual development from one perspective with reinforcement from other established technical and conceptual activities of specific disciplines.

4.2. Philosophy

The philosophy needed for a computer graphics program and curriculum development would be different depending on what level and focus is to be taken. In this general outline, a combination of a number of the philosophies of institutions presented in Chapter Two seems appropriate with special interest in the Transpersonal, the Subject/Disciplines, and the Cognitive Process Orientations. One element of a program should pertain to it's evolutionary nature.

4.2.1. Evolutionary Nature

A proposed computer graphics curriculum as well as the computer graphics program needs to have an evolutionary nature. Computer graphics is still in its

formative years, requiring up-dates to be made to hardware and software to stay abreast of the technological advancements. Since students will be exposed to a variety of changes, the methods of teaching relative to the many curriculum orientations need to be experimented with to determine which approach or approaches reinforce learning for students. This applies to the conceptual level of students. For example, when students have fixed patterns of response, that is, seeing things as black or white with no middle areas, they are considered to be at the low level of conceptual development. At this level, students need structure within their environment to feel secure. As their conceptual level raises, less structure is needed and students are able to deal with more complex concepts by relating and comparing different systems of interactive variables.

The instructor needs to be able to: determine the conceptual level; create an environment which is matched to the complexity of the student; and increase the integrative complexity of the individual by gradually offering more complex stimulation to the student. Relative to the teaching methods instructors should use, Joyce states:

> For students of low conceptual level, tasks or educational approaches of low complexity, with high sequence, and a clear establishment of the rules would be indicated. For students of high complexity, a very emergent structure with higher complexity and an interdependent social system would be indicated....For students of low conceptual level, he is to be fairly controlling, clear in his directions, supportive, but fairly direct. When dealing with students of high conceptual level, he needs to be much more interdependent and mutual, placing more of the burden for learning on the students and helping them to develop their own structure [11].

Within the curriculum structure, this means that the initial course offering should have quite a bit of structure going toward less structure as the student's conceptual level raises. This assumes that regardless of the student's conceptual level, they will need structure within the beginning courses to develop an understanding of the technical material. The instructor must be sensitive to the student's conceptual levels and develop a flexible orientation enabling them to adjust their modes of teaching. The curriculum should be designed to anticipate student's conceptual development and thus offer less structure in the curriculum by establishing courses which use group investigation, abstract thinking, and self directed study at the higher levels of instruction. The curriculum would be designed to require the initial

structured courses while permitting students to choose among a variety of courses which are more conceptual and abstract in nature at the higher levels. The instructional value of each course and the modes of presentation should be examined and adjusted to perfect the structure through evolutionary steps.

4.2.2. Maximize Interaction

As discussed in Chapter Three, the importance of student-student interaction is of much value especially within a creative environment [10,15]. Since computer graphics can offer a visual representation of many environments which bridge many disciplines, the scope and knowledge are very interrelated, making it difficult for one individual to grasp all its aspects. Student-student interaction permits the mutual exchange of ideas, relationships, concepts, modes of visualization and specific knowledge from a wide range of perspectives and backgrounds. Students with strengths in programming skills, color theory, and composition are able to exchange and grow through the mutual interaction and thus develop a broad range of skills and concepts otherwise not attainable.

As mentioned earlier, the interaction of faculty and students is also important. The instructor, keeping in mind the student's conceptual level, needs to help students find directions to take rather than tell them what to do. Within the creative sense, instructors need to help students find their own means of expression regardless of how related or unrelated the student's aesthetic sense is to that of the instructor's.

The third type of interaction pertains to computer access. Students need time to experiment with the computer graphics system to reinforce their understanding of 3D graphics, software, and programming [9]. Students should be able to work with a system as much as they wish to aid in their understanding of the operating system, the use of the editor, word processing, and general workings of the computer. It is hoped that students are able to have twenty-four hour access to the computer. If this is impossible, then as much access as possible needs to be offered.

4.2.3. Problem Solving

The problem solving and investigative approach are appropriate modes of learning in a computer graphics

curriculum. This enables students to discover visual concepts along instructors specifications in structured classes. The problem solving skills developed in the initial courses can later be used as a means for discovery and research in the higher level, more self directed courses. Problem solving techniques reinforces students thinking and offer a broad perspective of solutions to problems.

4.2.4. Establishing a Creative Environment

Establishing a creative environment for students' intellectual growth is very necessary in a computer graphics program, since the technology may tend to expect students to work in unfamiliar ways. The computer requires one to go through sequential processes to interact with it. There are initially objects to be designed which must be tested to determine if they are usable by the computer. Then after testing the objects, they are placed in relationship to each other to design a composition. All the steps during the initial phase must correspond to the accepted models of the computer. This tends to develop technical perfection but is only the ground work for the creative interaction. Choices of color, design,

composition, and image quality are performed after the technical development. It is imperative that students be given regular critiques to guarantee that they are developing their visual, expressive, and conceptual ideas. Students should be encouraged to develop their own creativity in computer graphics and to experiment with the computer to develop their own understanding and aesthetic with respect to the potentials of computer graphics.

The environment needs to keep evolving in an attempt to understand the most appropriate means for artistic interaction by designers, architects, and artists. Higher level research courses may be designed to permit students to test various functional operations of the computer software and peripherals to determine their acceptability for artistic usage. The creative environment should support gallery showings, student competitions, and constructive criticism in an attempt to keep a focus in the arts. Also, after the computer generated images are recognized within the community, writing of grants will be strengthed by using the images as exemplars.

4.3. Computer Graphics Curriculum

Developing a Computer Graphics Curriculum in the Arts is an activity which must consider the desires of: faculty from each discipline involved; the needs of industry and society; and individuals to establish objectives [19]. Saylor [27] explains the steps in curriculum planning as four principal phases.

1. Setting major goals (and domains) through basic data analysis.
2. Designing curriculum domains, each related to one major set of goals.
3. Anticipating curriculum implementation (instruction).
4. Planning curriculum evaluation.

We are concerned with number one, two, and three in a general sense and expect that more specific guidelines would be established through committee interaction. The course descriptions given are meant to offer information for further study and/or possible choices in respect to establishing precise curriculum guidelines for a proposed program in computer graphics for students in the fine arts, design, and architecture. Students in other arts areas such as the performing arts would be permitted to be involved in the program and propose courses to be developed in their particular field. The course titles are

meant to function as domain areas and/or as one or more courses.

4.3.1. Faculty Seminars

In order to establish a base of faculty members with expertise in computer graphics, seminars in computer graphics would be taught. These would include willing faculty and staff members as well as graduate students which have developed experience in computer graphics through self directed study. The object of the seminar would be to exchange computer graphics information, attempting to bring all the individuals up to a similar of level of expertise. It is anticipated that instructors would study other computer graphics areas on their own and search for possible computer graphics applications in their area of interest. Design and architect faculty could examine CAD/CAM software to define uses within their specific areas while fine arts faculty could look at new ways to teach color theory and composition through the use of the computer.

4.3.2. Core Courses

The core courses are meant to be prerequisites for higher level courses. Students would develop strong backgrounds in the general workings of computer graphics, enabling them to take any of the high level courses. The first two courses are meant to be taught as mutually supportive courses for beginner in computer graphics.

4.3.2.1. Introduction to Computer Graphics

This course would have a survey structure, beginning with a history of the computer with emphasis on how the design of computers has evolved, discussions of the current uses of computer graphics, viewing computer generated images and some hands on experience through the designing and execution of a computer generated image. This course would focus on the obstacles necessary to overcome to use the computer as a visual tool.

> The biggest obstacle to initiation of computer art in schools is neither the computer, school curriculum, nor class size. It is ourselves [1].

The fact that a computer is call a "computer" suggests that it has a mathematical base. Artists seem to have a phobia about technical learning although many artistic

endeavors have a strong base in technology. For example, photographers use the zone system to determine the proper exposure and development times for complete control of contrast and image quality. The zone system uses exact mathematical formulae to control the photographic image. In painting and pottery, artists mix their own pigments in order to have the degree of control over color they wish. Of course, the photographer, painter, and potter need not develop this degree of technical knowledge about their medium. It depends on the degree of technical control these artists desire. Artists may want to understand the concepts of the zone system or pigment mixing but have little use for detailed knowledge. The degree of technical knowledge that an artist needs to make computer generated images can vary as well.

The problem with artists working with the computer is that the technical side appears to be there right in the beginning. It must be dealt with before artists feel comfortable working with the computer. It looks as thought the technical side of the computer medium comes first, not by choice but by it's presence. If the approach to photography was to begin with the zone system, many artists would be turned away from the photography medium.

Many people including artists grow up having math or computer phobias. If we can look at the computer as a tool for image generation or as a problem solving aid then there is no need to fear the computer.

The basic goals of the Introduction to Computer Graphics course are to free the student of math and computer phobia, explain computer programming as a means of communication with the computer, present a developmental history of the computer, and the basics of digital and analog electronics as well as present a variety of computer generated images in an attempt to demystify the computer.

4.3.2.2. Basic Programming in Computer Graphics

In conjunction with the Introduction to Computer Graphics a basic computer programming would be offer to aid in the the understanding of computers and programming. The word "Basic" in meant here as the Basic computer language. This language was chosen since it is very easy to work with and understand. The course would focus on having fun with programming by permitting students to write programs that would draw on a vector screen (i.e. line drawing screen). The final project would be to write

a program which used lines to construct a visual composition on the display screen.

4.3.2.3. 3D Computer Graphics

The scope of this course would be to introduce 3D Computer Graphics to the students by assigning specific problems. First of all, the student should develop a good understanding of 3D computer graphics space. This can be accomplished by assigning the construction of objects which are to be used at a later to compose a computer generated environment. This is similar to the approach used in the beginning computer graphics courses at the Ohio State University [28]. Students are given assignment which permit them to investigate the 3D computer space and establish relationships to the "real world" to reinforce their concepts of 3D computer space. Students are given a lot of structure in this initial course to insure that they develop the necessary technical competency. The final assignment would be to express some visual concept which is would be predetermined in a consultation with the instructor. The student would be evaluated in a private critique with the instructor to determine how successful the student was at expressing the desired visual concept.

After this, an open critique would be given made up of students, faculty, and other students involved in the computer graphics program. It is important that these critiques stimulate discussions about artistic thought patterns, concepts, merit, and style of each art work in a constructive and positive manner. Each of the follow-up courses would finish in a similar fashion by having a student-faculty critique and a group critique. The critiques would serve the dual purpose of student evaluation and course evaluation. From this information: courses could be altered when necessary; teaching methods could be improved; and students which require more attention could be discovered and helped.

4.3.2.4. Introduction to High Level Programming

The realm of this course would be to develop good programming and interactive skills in a high level computer language. For example, "C", Pascal, and Fortran are in use at a number of computer graphics facilities. It is important that this course be taught in the language used to program the existing software at the facility in order to facilitate interaction with the software. The concepts of data types and constants (i.e. integers,

floating point, character and strings), arithmetic expressions, do loops, while loops, and if/then statements would be studied in this course. Concentration on good programming style and program "commenting" would be done. Some consideration of programming efficiency would be made to help students understand that there are a number of ways to write programs. The final assignment would be to write a program which used a majority of programming conventions covered by placing objects in various configurations on a vector screen. Students would need to be able to use the program to do dynamic manipulation to perform a simple animation. This course would present a review of algebra and trigonometry to aid in the development of the simple animation. This course, although considered a core course, would be a prerequisite only for high level courses which required the programming skills. It is anticipated that students would be motivated to take the course by assigning the production of an animation at the end of the course.

4.3.3. Elective Courses

The elective courses are designed to meet the needs of specific disciplines such as fine arts, design, and

architecture as well as the desires of industry and individuals. The courses tend to be specific toward one of the three groups mentioned as opposed to the core courses which try to satisfy the desires of all three groups to some degree within one course. All the courses would offer less structure and more self direction depending on each students conceptual level. Group activities would be encouraged in various research type courses while other courses would permit greater flexibility and self direction. The courses concerned with programming would use a vector display to develop interactive controls of the screen through programming. The majority of courses could be taken a number of times by attaining permission and outlining goals with the instructor.

4.3.3.1. 3D Computer Animation

This course would introduce 3D Computer Animation methods. Students would be given a choice of writing programs to produce animations and/or use a "key frame" animation system which takes interactive key board commands to control dynamic motion. The focus would initially be on producing a smooth and continuous animation of ten seconds. The second project would be to

produce expressive motion in an animation. Again, students would be asked to describe their intended concept before beginning their final animation. Storyboards would be used to express and represent the students intent. Students would be permitted to work in groups if they desired to produce more complex or lengthy animations than individual efforts. The course would offer access to a number of peripherals and software for greater image control (i.e., paint systems, texture maps, and data generation). It would be possible to take the course a number of times by determinating goals for independent or group study.

4.3.3.2. Computer Graphics for Designers

Students would work with a number of CAD/CAM software packages to develop design skills. The structure would be similar to the established design courses. While using the CAD/CAM software, students would be asked to note desirable and undesirable attributes of the software in an attempt to determine better functional usages for designers. This information would be correlated to be used later in research courses. The main purpose would be to offer designers a chance to develop the technical skills

necessary for employment. Follow up courses would be offered for conceptual development and self directed study in visual thinking and problem solving. These course could be taken independently or as group studies.

4.3.3.3. Computer Graphics for Architects

This course would be the same as the Computer Graphics for Architects course except that architect students would use the CAD/CAM software to develop their technical proficiency in computer graphics. Again, records would be kept of the interactions with software, anticipating use in later research courses. Follow up courses would offer greater conceptual thinking and self directed study in visual thinking and problem solving. Architects would be permitted to work in groups or study independently by first establishing goals with an architect professor.

4.3.3.4. Man Machine Interface

This course would pertain mostly to design students although any student completing all the core courses would be permitted to take the course. Students would be ask to separate into groups which had a variety of students with

established skills. Depending on the students programming capabilities, other students specializing in computer graphics programming would be invited to participate in the group. The group would be asked to investigate any of the interactive computer graphics systems in the facility to determine better methods of interaction. The data compiled in the Computer Graphics for Designers and the Computer Graphics for Architects courses would be used as basic data for research in these areas. The focus of this course would be to research the methods of interaction with software and propose guidelines for improvement of the functional interaction with software and interaction with computer peripherals for artists, designers, and architects. It is anticipated that establishing this course would aid in acquiring research grants. It is also anticipated that the course could be taken a number of times in succession.

4.3.3.5. Advanced High Level Programming

This course would follow the initial Introduction to High Level Programming course. It would expand the programming knowledge attained in the first course by studying arrays, functions, structures, input and output

as well as computer architecture and procedures for working with large programs. The focus would be on more complex programs for data manipulation and development of interactive procedures to be used in computer graphics. It is anticipated that this course be taken in conjunction with the course in Interactive 3D Computer Graphics The final program would be to design images algorithmically which are capable of making various transitions through animation to other algorithmic images. The control would be totally through the use of the program thus implying that some form of interacting to be necessary. The images would be displayed on a vector screen in an attempt to get real time interaction.

4.3.3.6. Interactive 3D Computer Graphics

This course, taken in conjunction with the Advanced High Level Programming course would be directed concerned with the development of Interactive 3D Computer Graphics. Students would study the actual algorithms used to do 3D computer graphics and write interactive programs which use windowing techniques. The topics of 2D and 3D transforms, clipping, viewports, and hidden line removal would be covered in the first part of the course. It is anticipated

that this course would be divided in two or more courses depending on students acquisition of the information. The second part of the course would be concerned with raster techniques (fully shaded color images) of 3D computer graphics. Such topics as hidden surface removal, shading models, intensity and color and polygon meshes would be covered. After taking the first part of this course of study, students would be able to write special purpose programs of their own to perform the 3D "vector" computer graphics. The raster manipulation would be developed through completion of the second part of the course. The importance of the course is that student would attain enough information to begin research in computer graphics to improve the functional modes of operation as well as such things as image quality and animation capabilities. This should enable students to alter and improve existing software. The mathematical concepts needed for this course would be reviewed by the instructor when deemed necessary. It is anticipate that this course would begin to form a base of students for research and proposed writing of grants.

4.3.3.7. Conceptual Skills

This area of study is less of a course and more of a basis for research of concepts relative to computer graphics. Artists would be encourage to take this course to develop conceptual art activities. While other professionals would take the course to do independent study in their discipline. Areas of abstract thinking and conceptual analysis are to be investigated through independent study with faculty guidance.

The curriculum outlined has areas for additional courses as faculty and students determine their need. This permits the instruction to begin, keeping in mind that what is established may be improved when deemed so by faculty. The curriculum and modes of presenting the educational opportunities would be permitted to evolve and improve if a committee made up of faculty and staff with some input from students deemed the changes necessary.

4.4. Student Requirements

To establish a base of experienced students in computer graphics, the initial requirement of graduate

level students with an arts background is necessary. It is important that these students not have a technology phobia and imperative that they are able to be self-directed. These requirements are necessary to guarantee that the students will be successful in learning computer graphics and establish a foundation for future teaching assistants and creative researchers.

After a base of student teaching assistants is developed, some waivers of the requirements may permitted, to offer computer graphics to a broader base of students. Serious students in the arts at the junior and senior levels would be considered. It would still be important to require students without "technophobias" that have an adaptive nature. It is anticipated that students will apply to the program that have a programming background. Some preference may be given to these student although it is more desirable to admit students with a wide variety of interest in the visual arts as well as the performing arts.

4.5. Concerns

The concerns which were discussed in Chapter Two, relative to computer graphics, offer some insight here. They are to be considered as valid in relationship to the philosophy described in this chapter. A few other areas need to be considered when planning to implement a computer graphics program with in an established setting in the arts.

4.5.1. Cooperation

If a program is to begin, evolve, and become established a lot of cooperation among faculty, staff and administration will be needed. Since computer graphics is a relatively new technology, faculty will need to learn new skills to function with this medium. There needs to be mutual support of faculty through an exchange of information and ideas. A common goal of using computer graphics in the most applicable ways relative to specific discipline areas needs to be made. Faculty must support each other in an attempt to discover the best uses of the available technology. Most of all, it must be realized that no one particular person will know everything there is to know about computer graphics, thus faculty should

rely on the information of the group to develop a better understanding of computer graphics. It needs to be noted that faculty should not be required to use computer graphics. Rather, seeing the benefits their colleagues reap from the technology should encourage interest in computer graphics.

4.5.2. Need for Money

Computer graphics requires a large investment in equipment and software plus maintenance and operating cost. The cost of hardware continues to improve, but regardless of this, computer graphics will continue to be costly. Because computer graphics becomes more cost effective, the complexity of image quality and conceptual manipulation tend to go up, more than off setting the improved price performance. Realizing this fact, requires institutions to look for other financial avenues. Grants will need to be written to support the computer graphics program. Areas of research need to be delineated to begin developing images to support the grants for research. Industry should be identified which support computer graphics activities and grants need to be written to attract their investment interest. Also the local

community, which have interests in the arts, need to be identified. At the present time, large production houses are producing expensive computer animations which only large companies can afford. There exists a broad area of interested advertisers and companies which would be able to purchase animation and advertising in a middle price range.

CHAPTER 5

Conclusion

The information analyized in this document indicates that it is difficult to outline a specific computer graphics curriculum in the arts. A computer graphics curriculum has many areas of interest which must be satisfied, making it very difficult to develop a curriculum structure without specific knowledge about the desires of the students, society, and the many interested disciplines. Since the computer graphics field is growing very rapidly, it is difficult to outline specific technical knowledge which should be taught that will be relative in a number of years. This fact requires that students learn the processes of computer graphics rather than the specifics of a certain computer graphic software package. Learning to use a variety of computer graphics software could reinforce the general concepts relative to computer graphics. This will give students a "feeling" for adapting to various types of computer graphics software written to produce similar results plus develop a general and longer lasting understanding of the working of

computer graphics. An advantage as well as a disadvantage of computer graphics is it's interrelatedness to other disciplines and fields. Computer graphics can be used by architects, designers, fine artists,(i.e. the visual arts as well as the performing arts and the sciences.) It is difficult to know at what point in an arts curriculum the development of relateed disciplines needs to stop. This is why the computer graphics curriculum structure proposed in chapter four was set up to allow students and faculty to have an active hand in requesting computer graphics courses in a specific discipline area. The interdisciplinary nature of computer graphics should be viewed as an asset and an attempt should be made to develop positive relationships with other disciplines.

Since computer graphics is an interdisciplinary medium it has some relationship to practically every educational endeavor. It must keep the channels open among other disciplines to further the informational base of computer graphics while advancing computer graphics capabilities with respect to artists and designers. Courses with a problem solving structure should be offered to expand the knowledge of and the capabilities of the computer graphics system. These courses need to deal with

accepted and new ideas in computer graphics. Artists and designers need to have input into the design of computer graphics systems.

> Artists have been regarded not as superior craftsman but as members of an intellectual class that can be trained in ideas in the same manner as other intellectuals [15].

A number of articles and books refer to the need for integration of the logical and intuitive ways of thinking as a means of solving many future problems [25,8,32]. It is expressed that a Renaissance is upon us and it is time to reunite the arts and sciences. Computer graphics has the capabilities of bringing this about if we can keep from alienating the artist in the learning process. This makes a case for desiring to teach artists and designers in environments which are conducive to learning. To do this, instructors need to keep in mind the development of the student's conceptual level, the functional intelligence (i.e., the students natural potential, motivation, and environment) of each student and the realization that there is a need for a flexible approach to choices and usage of the curriculum orientations. The orientations which seem usable in a computer graphics

curriculum are the Transpersonal model, the Subject/Disciplines model, and the Cognitive Process model. These are to be supported by other curriculum orientations as the instructor and curriculum committee see fit. Much of the curriculum needs to be tested through a trial and error approach to see if the software and modes of education are workable. Permitting artists and designers to express their visual ideas with a computer graphics system is a fast and straight forward manner to determine the pitfalls of the system and the education of students.

What seems to be a necessary ingredient for a computer graphics curriculum is to develop a flexible attitude toward the teaching of student. Using the curriculum structures and concepts of a number of curriculum orientations, choosing the best elements of these orientations and using these elements as a starting point seems the way to begin.

> This tendency to rationalize a curriculum pattern in terms of a principle, at least in theoretical statments, while overlooking the relevance of other equally important considerations is in effect a gross over simplification which has many undersirable consequences. One is a kind of myopia in developing and implementing curriculum designs. The patterns for the scope and sequence appropri-

> ate for social studies have been discussed as if they were equally appropriate for all subjects. The designs which have been tested only on the elementary level have been extended into high school without their appropriateness on that level [29].

A committee of willing instructors should be pooled together to sort through the most effective teaching styles, introducing these styles from their particular perspective and work together to determine the scope of the curriculum and the methods of teaching necessary for implementation. The committee needs to realize that the interest of student, society and the disciplines are not mutually exclusive. The curriculum needs to have the flexibility of design to: offer the best modes of instruction for students; develop interactions with industry and the community to support artistic interests in computer art and outline possible research projects; and work to develop the conceptual level of interacting with computer graphics and other disciplines. A curriculum is not a hard and fast structure. It should be able to instruct in the most effective manner for the particular subject matter; to expand the knowledge base of students and society by developing conceptual thinking in the computer graphics field.

Computer graphics is well on it's was to becoming an expressive tool of artistic merit. The potential to create new worlds and new ways of seeing and ways of expressing the human condition with computer graphics is limited only by our imagination and ways of thinking. The computer has great potential for creative thinking and imaging if we dare to expose artists to its potential and if we dare to take the necessary steps toward the future with the flexibility of a young sapling having it's roots planted in the earth permitting it's branches to be blown by the wind.

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